Climateworks CENTRE

# Climateworks Centre decarbonisation scenarios 2023:

## Paris Agreement alignment for Australia

NOVEMBER 2023

ACKNOWLEDGEMENT OF COUNTRY

We acknowledge and pay respect to the Traditional Custodians and Elders – past and present – of the lands and waters of the people of the Kulin nation on which the Climateworks Centre office is located, and all of the Elders of lands across which Climateworks operates nationally. We acknowledge that sovereignty was never ceded and that this was and always will be Aboriginal land. More information.

## ACKNOWLEDGEMENTS

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## ABOUT US

Climateworks Centre bridges the gap between research and climate action, operating as an independent not-for-profit within Monash University. Climateworks develops specialist knowledge to accelerate emissions reduction, in line with the global 1.5°C temperature goal, across Australia, Southeast Asia and the Pacific.


## AUTHORS

Michael Li

Lauren Croser

Mythili Murugesan

James Whelan



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# Contents

# Introduction

**Climateworks Centre has a decade-long history of using scenario modelling to inform debate around decarbonisation pathways for Australia's economy. Our latest scenarios show Australia can reduce emissions by 85 per cent by 2035.**

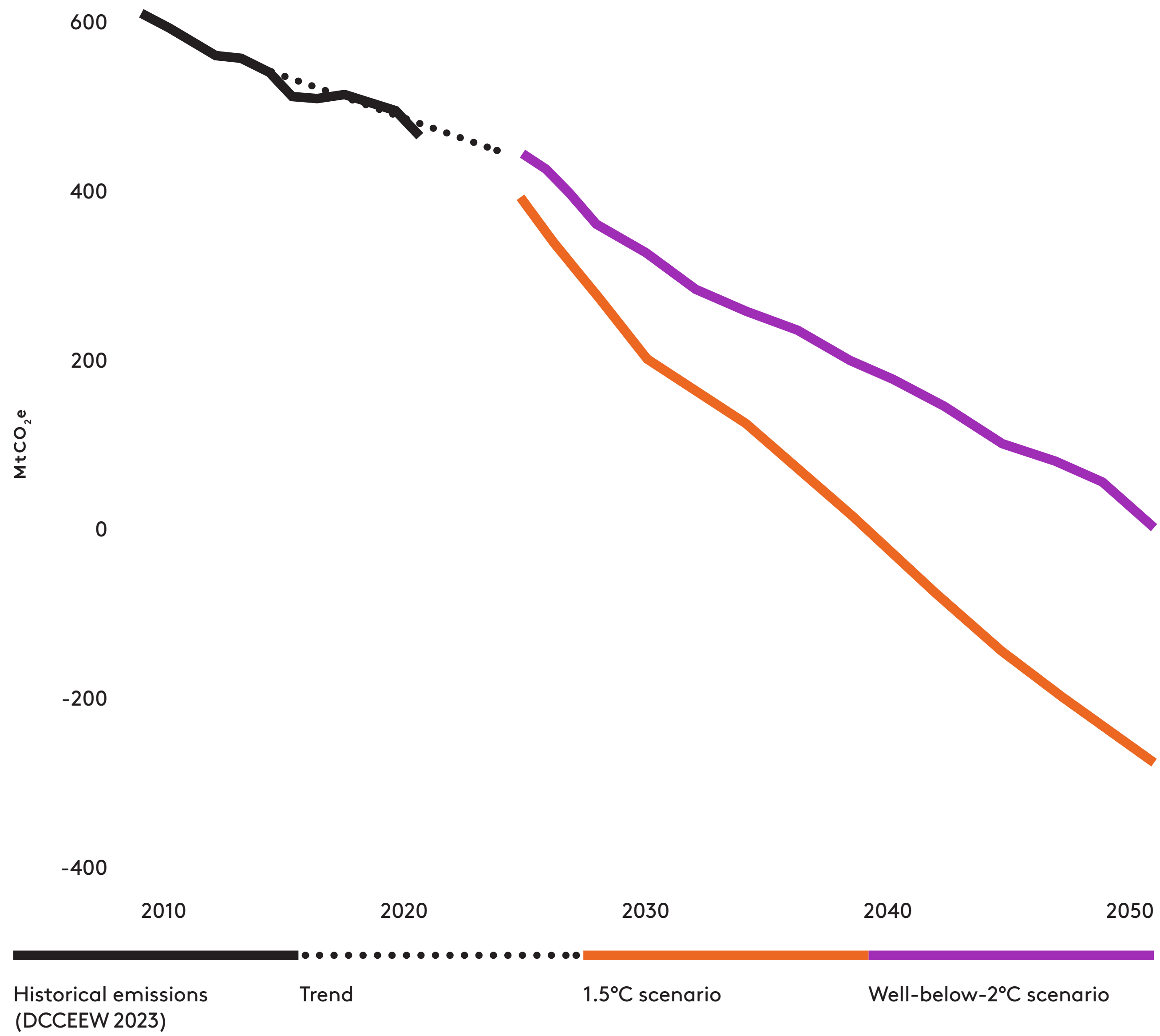
In the Oscar-winning, multiverse-hopping film *Everything, Everywhere, All At Once*, every decision a character makes creates an alternate possible future and a whole separate universe.

While the real world doesn't split into multiverses (as far as we know), this idea of multiple futures can be a helpful way to think about scenario modelling.

Climateworks uses scenario modelling to envisage how different levels of climate ambition might look for the Australian economy.

Using a tool called AusTIMES – developed over several years, in partnership with CSIRO – Climateworks modelled two possible emissions pathways, shown in the graph below.

**FIGURE 1: Emissions under well-below-2°C and 1.5°C scenarios**



The two coloured lines represent the lowest-cost options for decarbonising Australia's economy in line with the Paris Agreement goals – limiting warming to well below 2 degrees Celsius with an aim of 1.5 degrees – while also increasing the nation's economic activity and meeting energy demand.

The orange line shows Australia rapidly reducing emissions, doing its fair share of limiting global warming to 1.5°C.

The purple line shows a slower pace of emissions reduction which would help keep global warming well below 2°C. In this case, we have chosen a carbon budget in line with 1.8°C.

Aligned with global ambition for well below 2°C of warming, Australia's 2030 annual emissions would fall 48 per cent below 2005 levels. This extends to 61 per cent below 2005 levels by 2035, and net zero emissions by 2050.

If aligned with limiting warming to 1.5°C, Australia's 2030 emissions would reach 68 per cent below 2005 levels. By 2035, Australia's modelled emissions reach 85 per cent below 2005 levels, achieving net zero emissions by around 2039.

The Australian Government has legislated a target of 43 per cent below 2005 emissions by 2030.

To align with Paris goals Australia would need to urgently strengthen its 2030 target to at least 48 per cent – and ideally 68 per cent – below 2005 emissions, the scenario modelling results suggest.

This is based on the lowest long-term transition cost to Australia in line with a Paris-aligned carbon budget.

If aiming to cut emissions in line with keeping warming below 1.5°C, Australia would also need to aim for net zero before 2040, more than a decade sooner than its current commitment of 2050.

Similar research shows Australia reaching net zero in the mid- (Climate Council 2023) to late-2030's (Nicholls and Meinshausen 2022) to help keep warming below 1.5°C.

If some of the assumptions in our scenarios don't play out, like immediate action to reduce emissions in the next couple of years, then the net zero date would need to shift earlier than our modelling suggests and in line with other research.

# Cost-effective decarbonisation needs action across all sectors

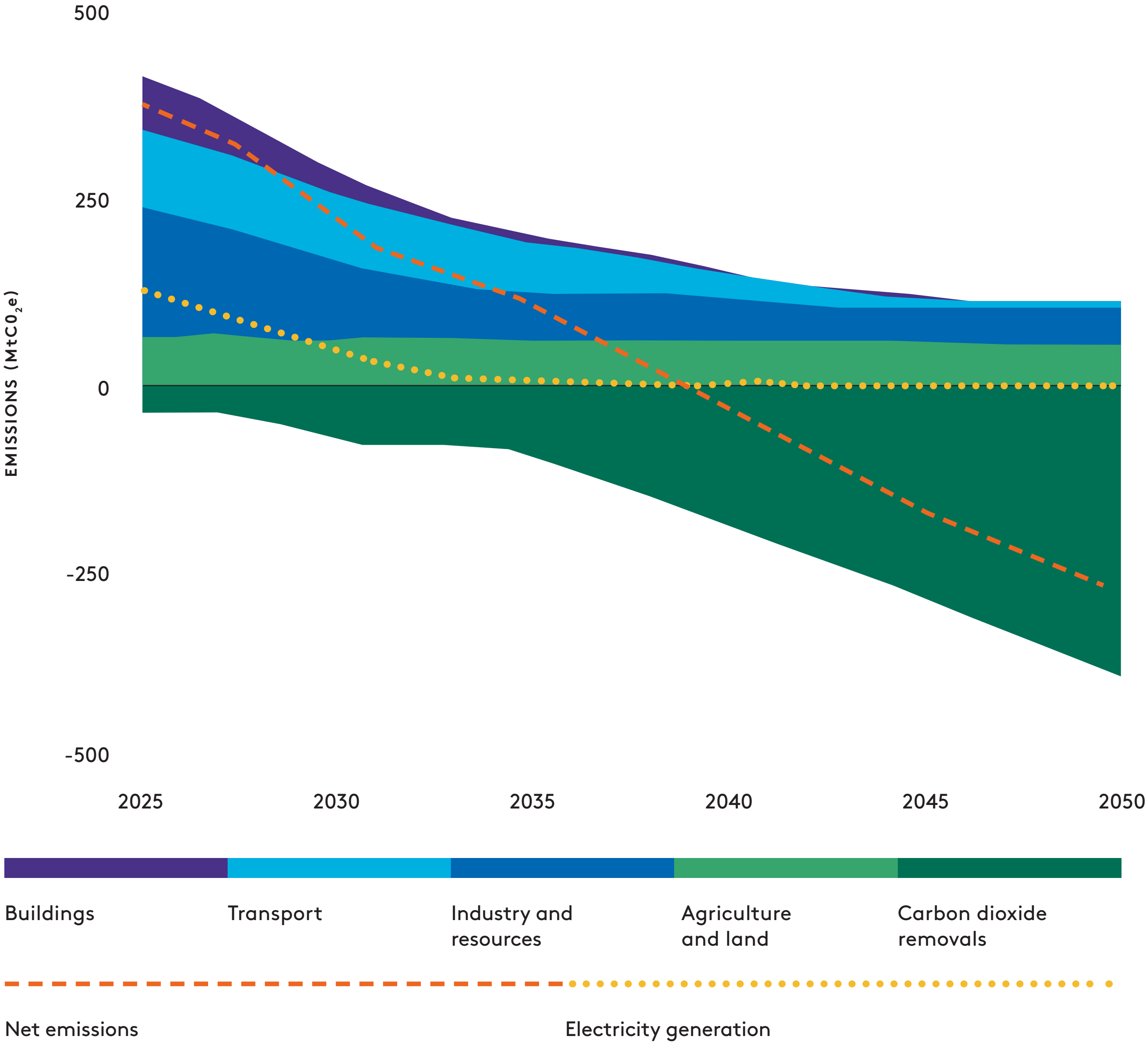
In July 2023, the federal government announced the development of net zero pathways for six sectors: electricity and energy, industry, built environment, agriculture and land, transport, and resources.

The government will develop net zero plans for each sector, setting out the policy actions and technology investments by which each can contribute to the government's overall climate targets.

Our modelling offers a starting point for developing sectoral pathways.

It provides an economy-wide view of the solutions available that can achieve near or net zero in each sector and net zero collectively – and the relative contributions of each sector to reducing emissions in a way that minimises overall costs across the whole economy.

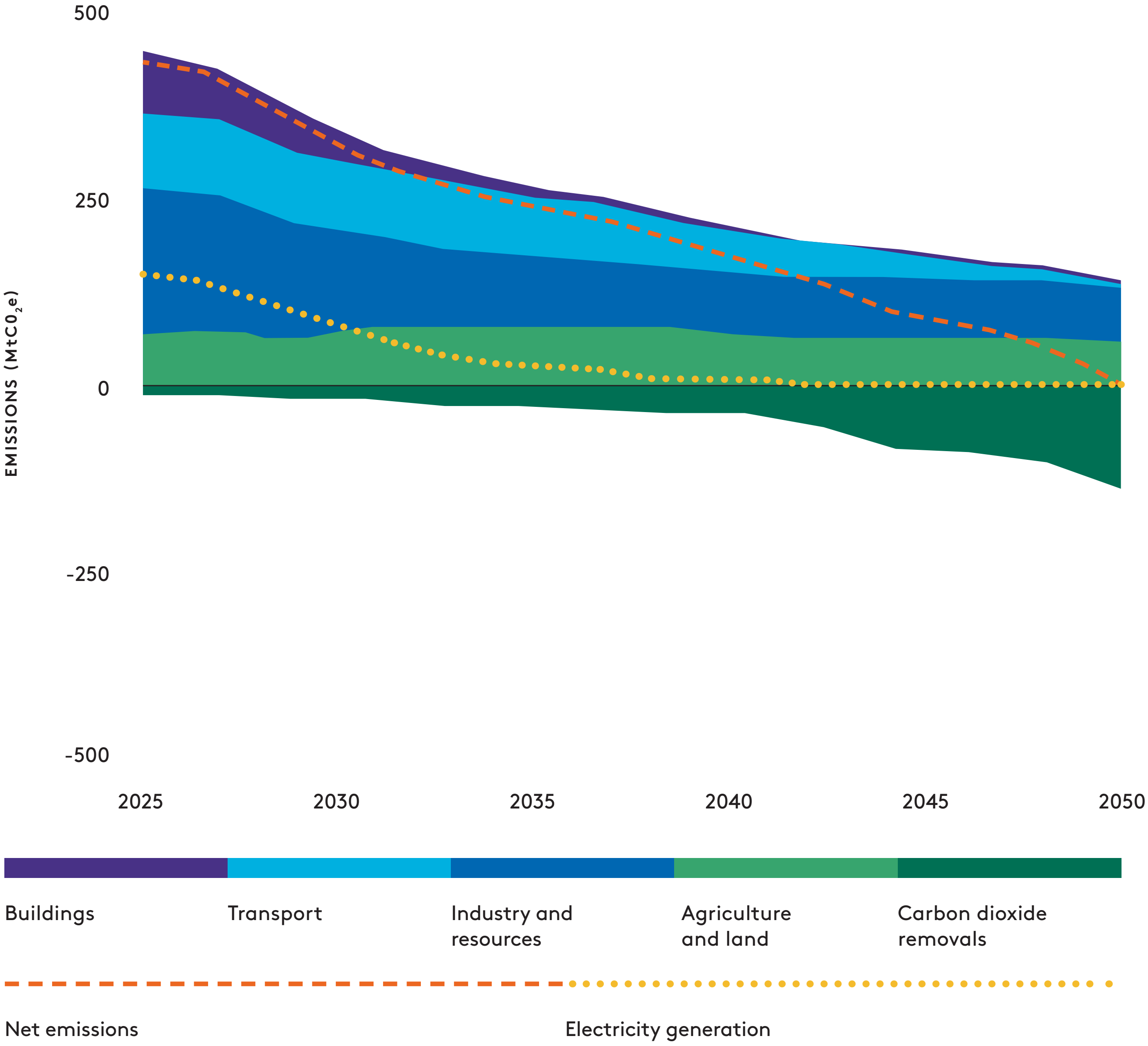
**FIGURE 2.1: Emissions by sector for 1.5°C (67%) scenario**



The technologies used to decarbonise the five sectors are broadly the same in both scenarios.

In both the well-below-2°C and 1.5°C-aligned scenarios, renewable energy backed up by storage makes up around 83–90 per cent or more of electricity generation by 2030, and nearly all electricity generated in 2050.

**FIGURE 2.2: Emissions by sector for well-below-2°C (67%) scenario**



## Our modelled scenarios include decarbonisation pathways for all economic sectors:

### Buildings:

Energy efficiency and electrification of housing plays a significant role in both scenarios. Housing energy efficiency improves by 41 per cent by 2050 compared to today's levels.

### Transport:

In the medium term until the 2030s, higher assumed demand for transport cancels out the emissions benefits of shifting to electric vehicles (EVs). Our 1.5°C scenario sees a higher uptake of EVs, which make up 73 per cent of new passenger car sales by 2030, compared to 56 per cent in the well-below-2°C scenario. This EV uptake is the main difference between the two scenarios in this sector. Our scenarios don't yet account for the benefits of mode shifts like public transport, cycling, walking and shifting from road to rail freight.

### Industry and resources:

Significant emissions reductions from industrial and resource sectors of 54–67 per cent by 2050 on current levels are possible, with earlier and faster uptake of electrification and hydrogen technologies through the 2020s and 30s driving more emissions reductions in the 1.5°C scenario. Informed by our modelling for the Australian Industry Energy Transitions Initiative (ETI) (Climateworks Centre 2023a), we find the potential for hydrogen to play a role in significantly reducing industry emissions previously considered hard to abate.

### Agriculture and land:

Agricultural emissions, mostly methane from livestock and nitrous oxide from fertilisers, make up a substantial share in both scenarios from the mid-2030s onward. The modelling finds opportunities to reduce emissions by adding algae to livestock feed and rolling out slow and controlled release fertilisers. Increases in production counterbalance some of these improvements in emissions intensity.

### Carbon dioxide removals:

Carbon dioxide removal is not a substitute for reducing emissions. In both scenarios, Australia needs to remove carbon dioxide from the atmosphere whether through nature-based sequestration or direct air capture (DAC). The 1.5°C scenario includes significantly more carbon dioxide removals, absorbing three times more carbon dioxide from the atmosphere by 2050 compared with the well-below-2°C.

# Clean electricity supply is central to Paris-aligned decarbonisation

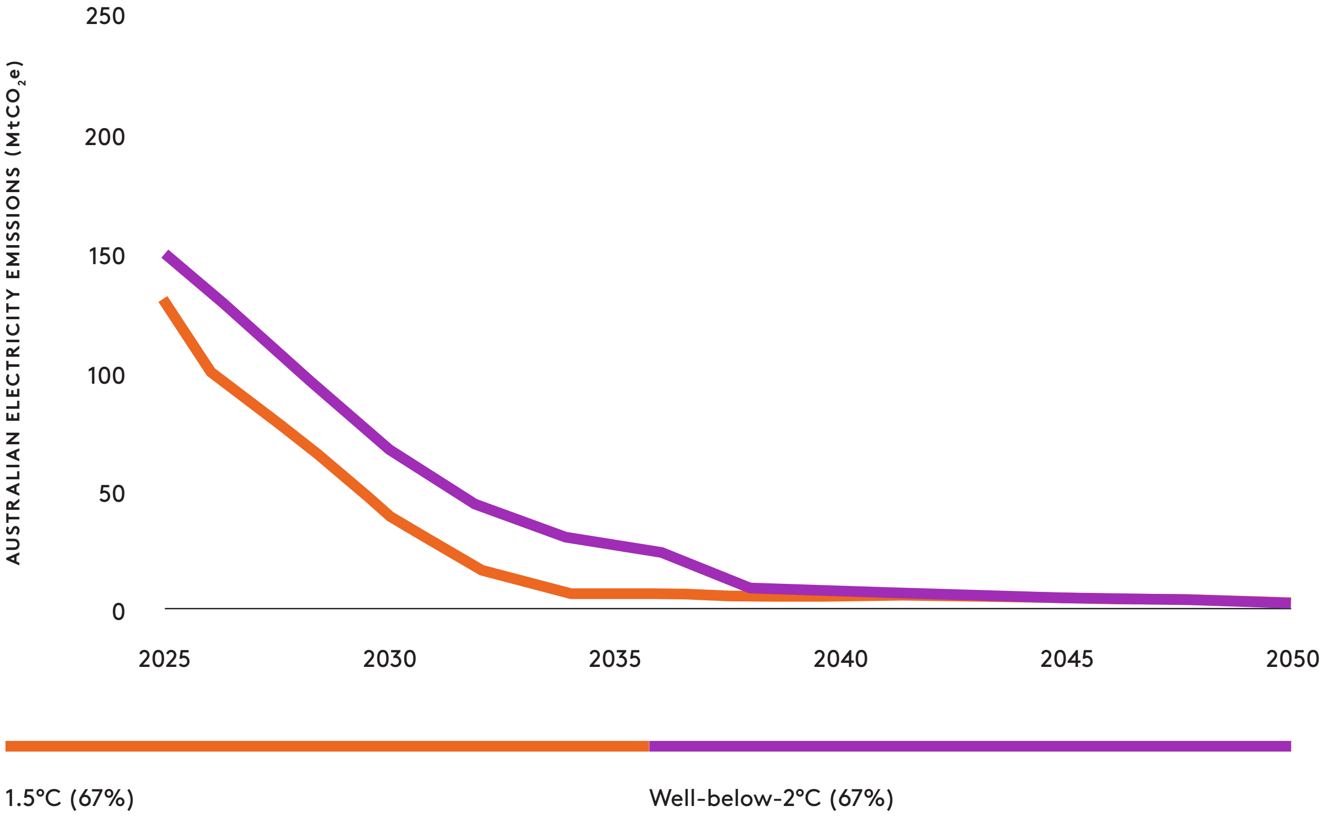
A decarbonised electricity system is crucial for Australia to deliver on its commitments under the Paris Agreement.

Representing a significant proportion of Australia's overall emissions reduction effort, decarbonising the electricity supply helps to reduce emissions in buildings, transport, industry and agriculture.

Renewable-powered electricity provides a low-emissions alternative for other sectors to shift away from fossil fuel sources – for example, shifting from petrol vehicles to EVs, from gas to electric cooking, and from coal to hydrogen produced with renewable electricity in industries such as steel-making.

Electricity emissions reduce rapidly in both our scenarios, reaching near zero emissions by 2034 in the 1.5°C-aligned scenario and by 2038 in the well-below-2°C scenario.

**FIGURE 3: Electricity emissions in 1.5°C and well-below-2°C scenarios**




Over the past decade, renewable energy prices have fallen dramatically. In many instances, technology costs have fallen even faster than forecasted (IRENA 2022).

This trend is one of the reasons our model shows renewable energy quickly displacing fossil fuels in Australia's electricity supply in both our 1.5°C and well-below-2°C scenarios.

# How fast can Australia decarbonise its electricity system?

The modelling suggests it's cost effective for Australia to rapidly replace fossil fuel generated electricity with renewable sources and go beyond its current target of generating 82 per cent of its electricity from renewables by 2030.

Coal-powered electricity generation disappears before 2035 in our 1.5°C scenario, and by the late-2030s in our well-below-2°C scenario.

Around the same time period, gas-powered electricity generation is greatly reduced.

By 2050, gas-fired power stations contribute less than 1 per cent of total generation, and would be used for what is known as 'firming'. This gas is not used day-to-day – it switches on infrequently, on the rare occasions that demand exceeds supply, to secure electricity supply to the grid.

**FIGURE 4.1: Electricity generation mix for 1.5°C scenario**

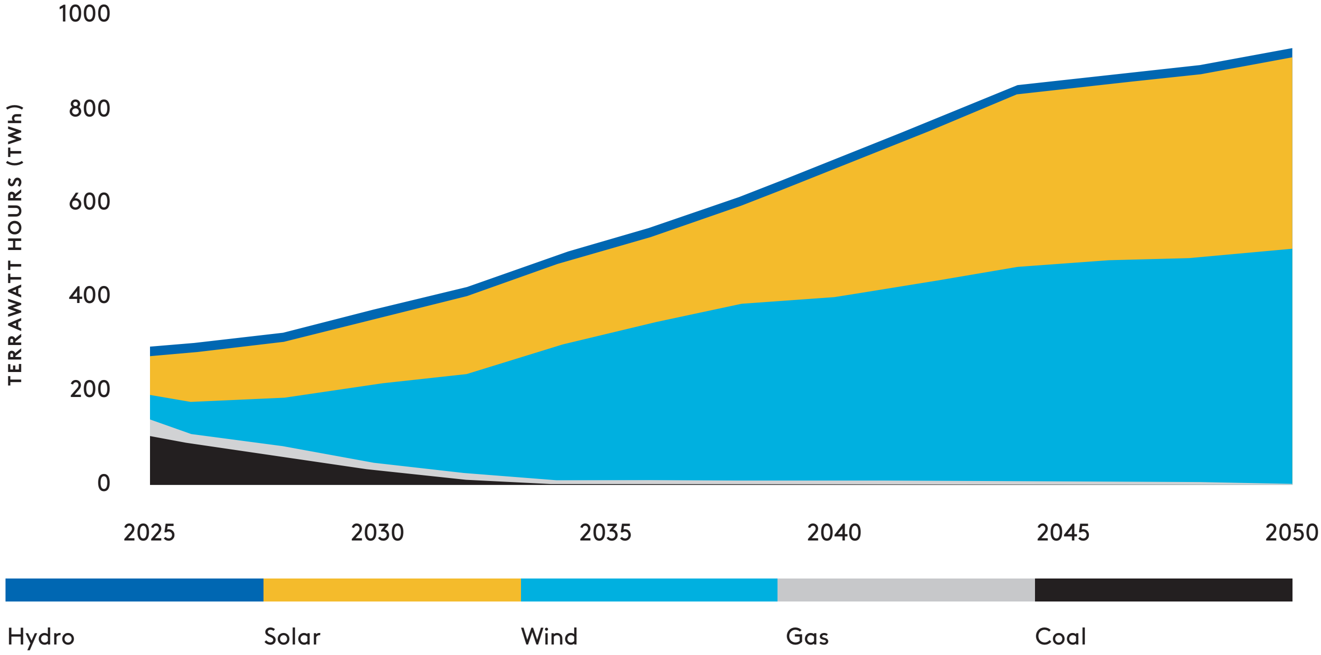
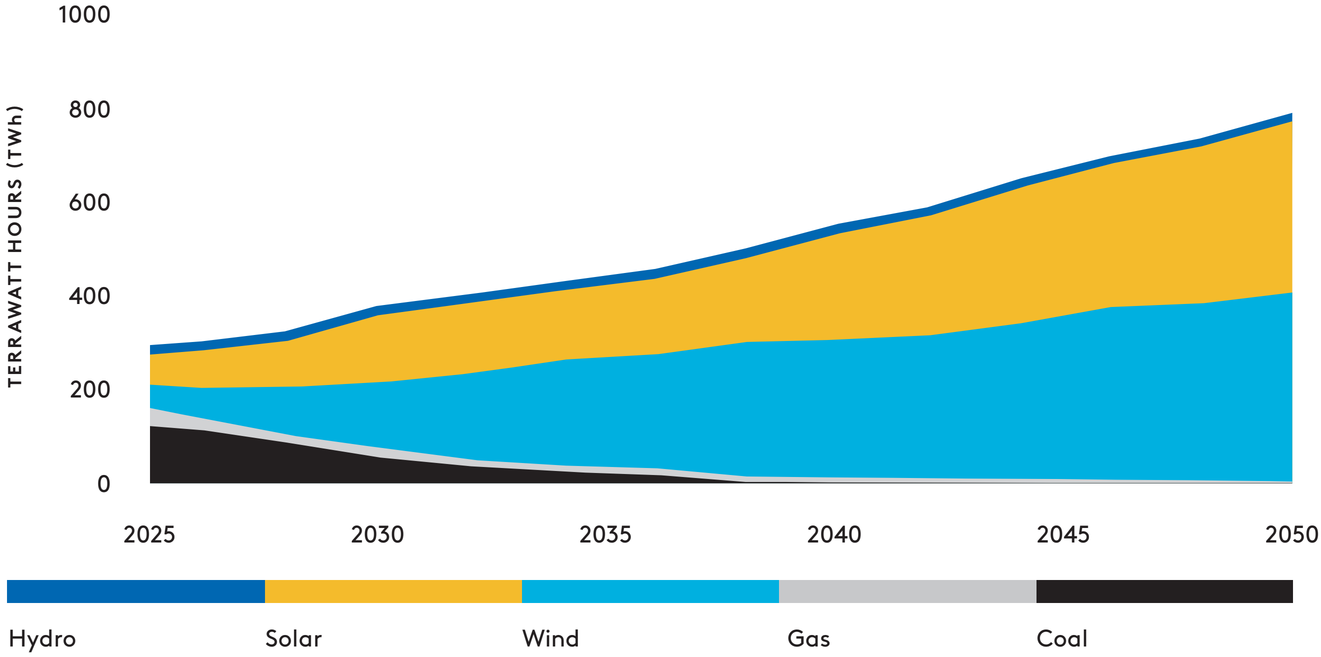



**FIGURE 4.2: Electricity generation mix for well-below-2°C scenario**




Our AusTIMES model doesn't fully account for the benefits of demand management, where either businesses, households or automated technology shifts energy use from periods of high demand on the electricity system towards times of low demand.

Demand management practices could reduce the grid's reliance on gas even more than what our modelling shows.

Meanwhile, in both scenarios, renewable electricity generation grows to 83–90 per cent share of generation by 2030.

This increases to nearly 100 per cent by 2050.

The graphs below show a breakdown of this increase in generation, displaying the levels of distributed solar (e.g. rooftop solar), utility solar (e.g. solar farms), hydro and wind generation over time in each scenario.

**FIGURE 5.1: Renewable electricity generation for 1.5°C scenario**

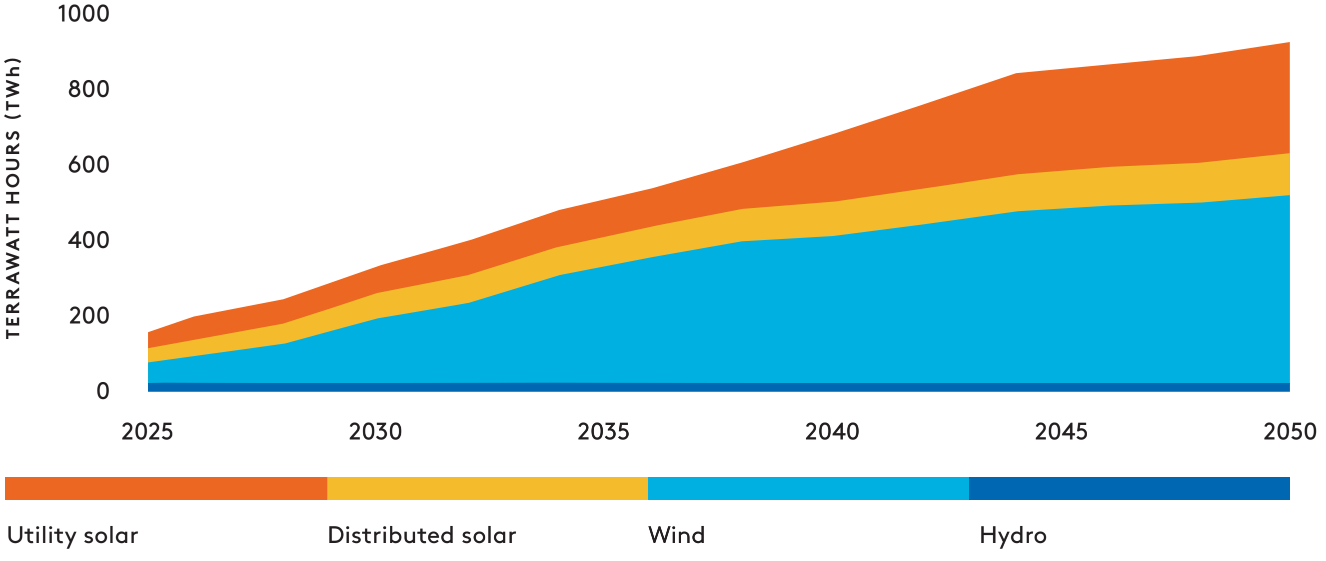
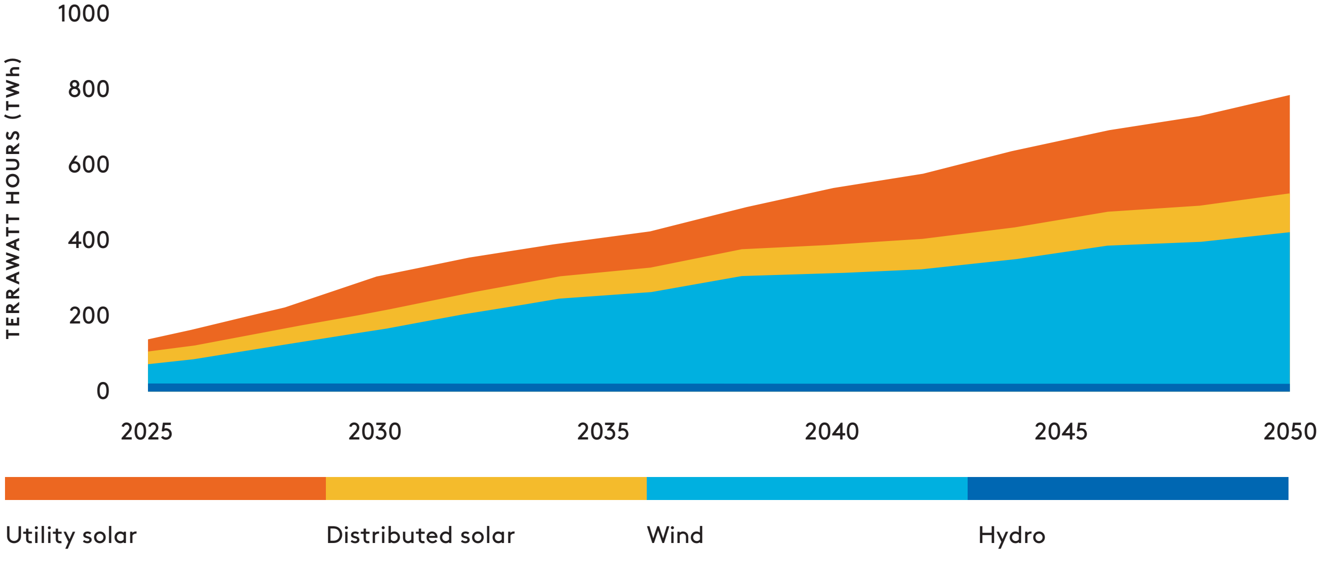



**FIGURE 5.2: Renewable electricity generation for well-below-2°C scenario**




Renewable electricity generation capacity, currently around 55 GW, increases in both scenarios to 137–151 GW by 2030 and 363–398 GW by 2050.

This level of renewable energy is backed by around 10–15 GW of battery storage by 2030 and 44–55 GW by 2050.

In both scenarios, the overall size of the electricity system increases.

The rapid increase in renewable electricity is doing more than just filling the gap left by decommissioning coal and gas generation – it's also expanding to enable the electrification of other sectors of the economy.

# Modelling shows hydrogen can play a role in industry

The inclusion of hydrogen is one of the most significant changes in our model since our previous economy-wide scenario release in 2020.

Support for hydrogen technology has increased substantially in recent years, both internationally and locally through government programs such as Hydrogen Headstart (DCCEEW 2023b).

Hydrogen could potentially be used in industry processes requiring heat, in transportation through the use of fuel cells, and as a replacement for natural gas in buildings.

Neither of our modelled scenarios show a role for hydrogen in buildings, passenger transport or short-haul freight, where electrification is more cost effective and more readily available to replace fossil fuels.

The modelling shows hydrogen can play a role in industry, long-haul freight and maritime shipping if it becomes commercially viable for these sectors. In our scenarios, domestic hydrogen demand grows to 304–394 petajoules by 2050, or around 11–15 per cent of total energy demand in 2050 across Australia.

**FIGURE 6.1: National energy use and share of hydrogen for 1.5°C scenario**

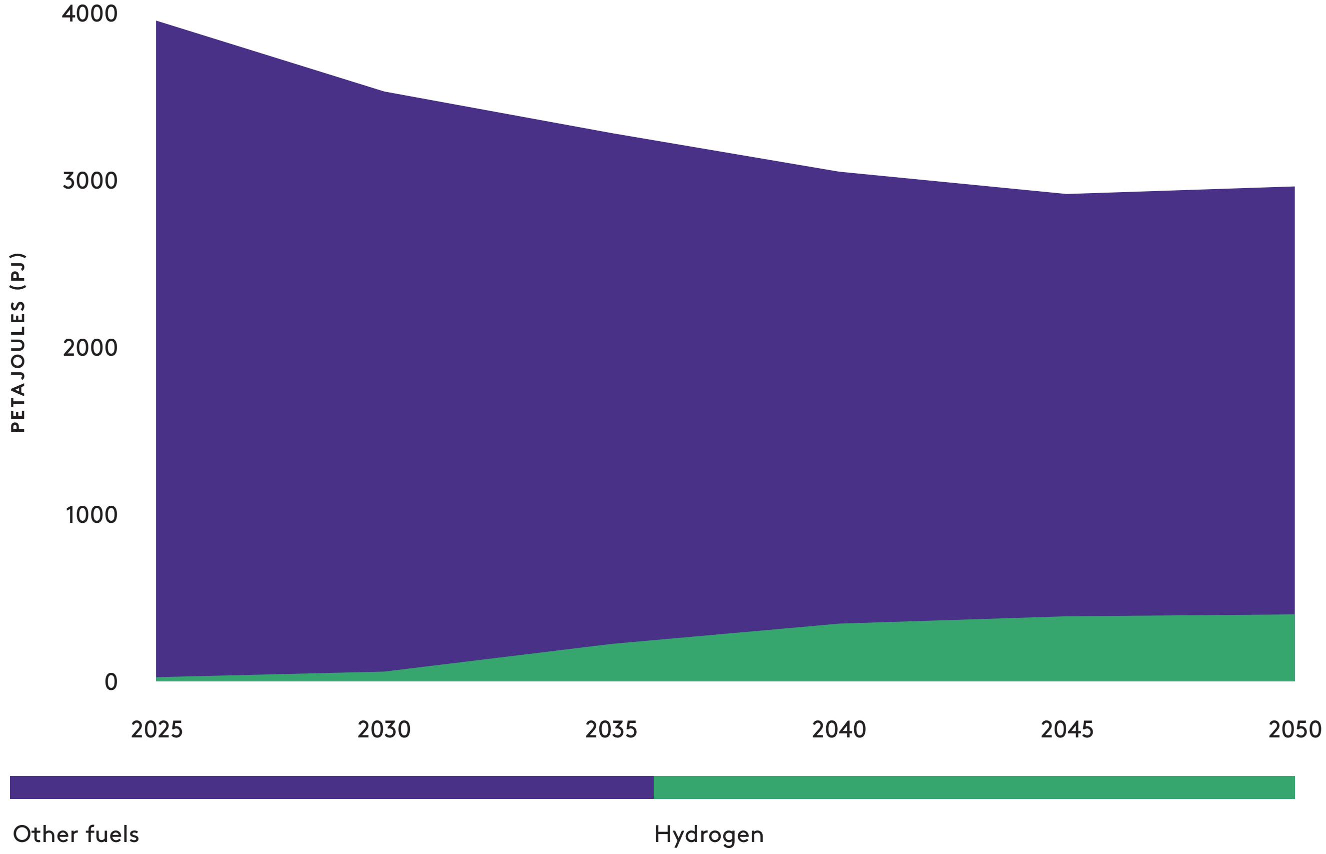
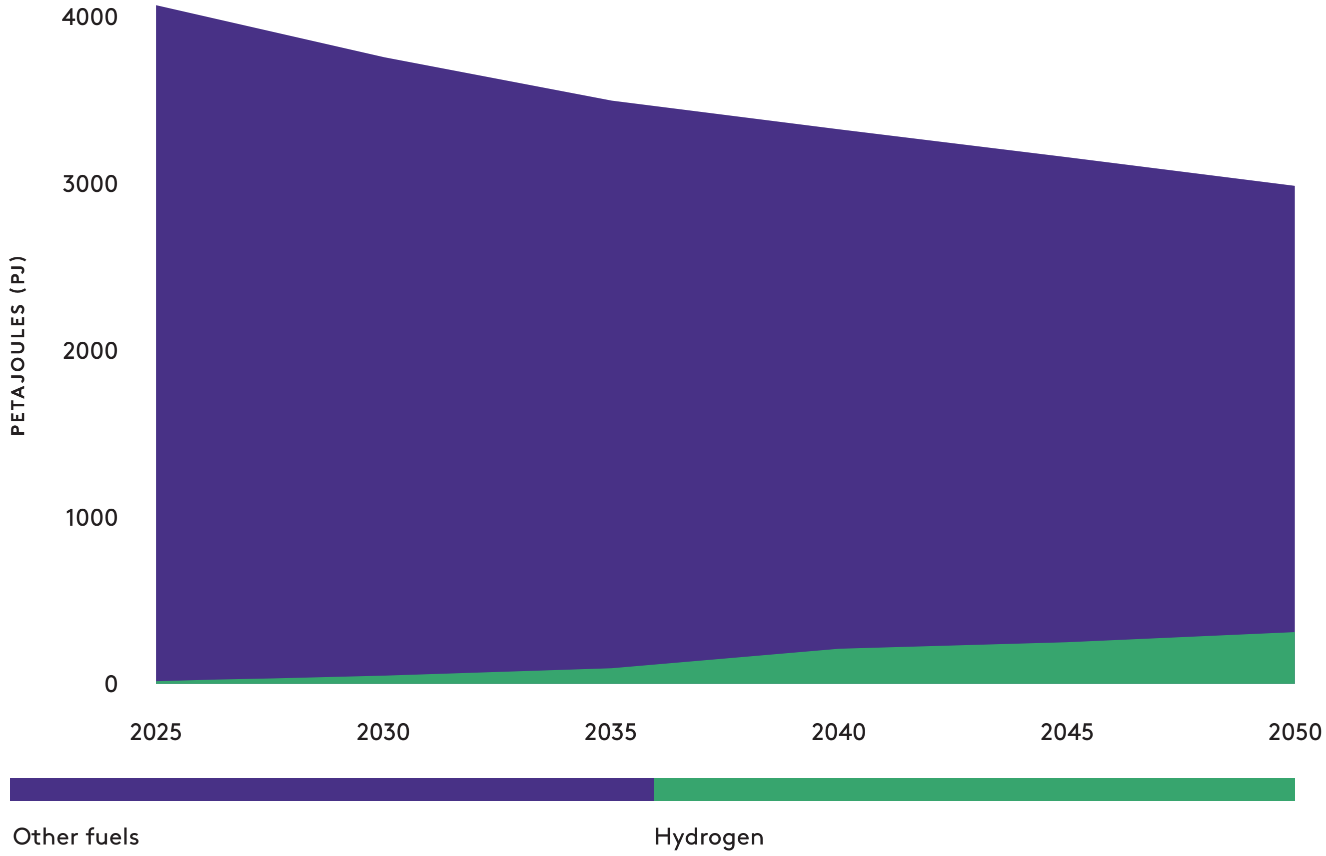



**FIGURE 6.2: National energy use and share of hydrogen for well-below-2°C scenario**



When talking about hydrogen, we're actually talking about several distinct technologies – some of which create greenhouse gas emissions.

Our modelling accounts for three different types of hydrogen production technologies:

**Green hydrogen:** Produced by splitting water into hydrogen and oxygen using a renewable electricity-powered electrolyser. This process does not create any greenhouse gases.

**Blue hydrogen:** Extracted from natural gas using steam in a process called 'steam reforming'. This process releases greenhouse gases, but these gases are captured and stored.

**Grey hydrogen:** Also uses steam reforming but the resulting greenhouse gases are released into the atmosphere.

You might also hear about brown and black hydrogen. These are produced using coal and do not play a role in decarbonising the economy.

**FIGURE 7.1: Hydrogen production for domestic use in 1.5°C scenario**

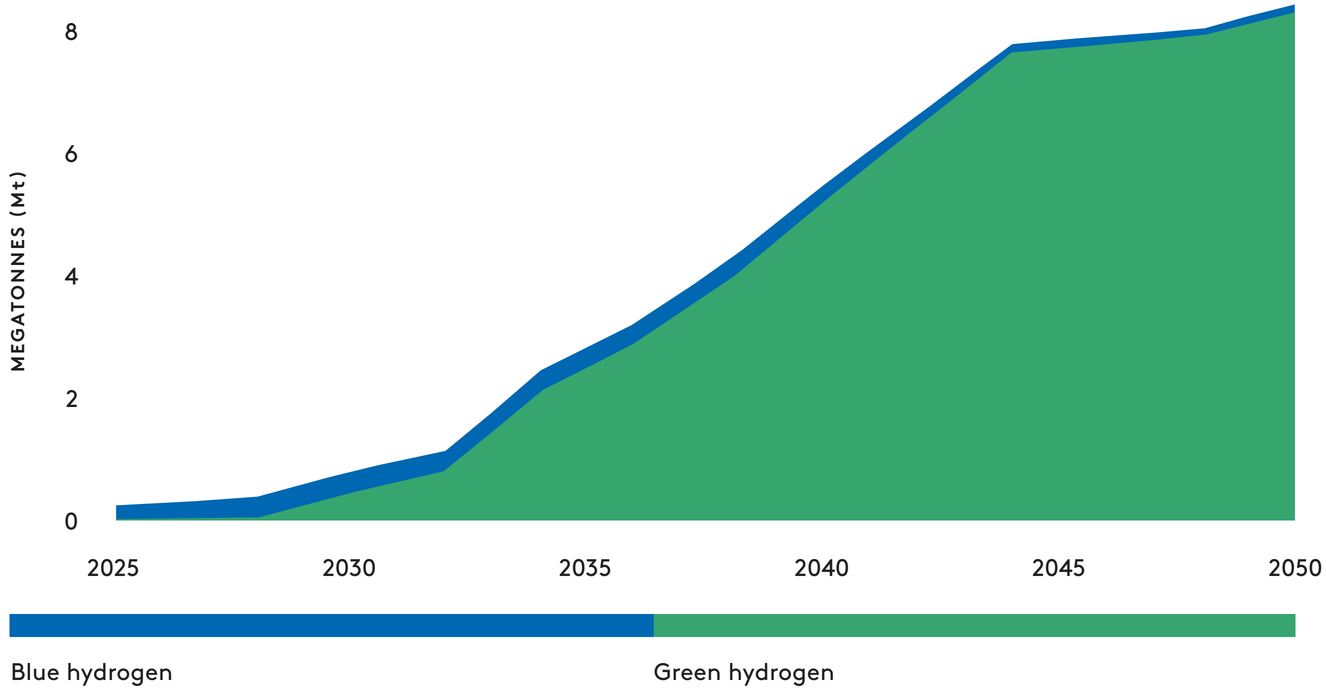
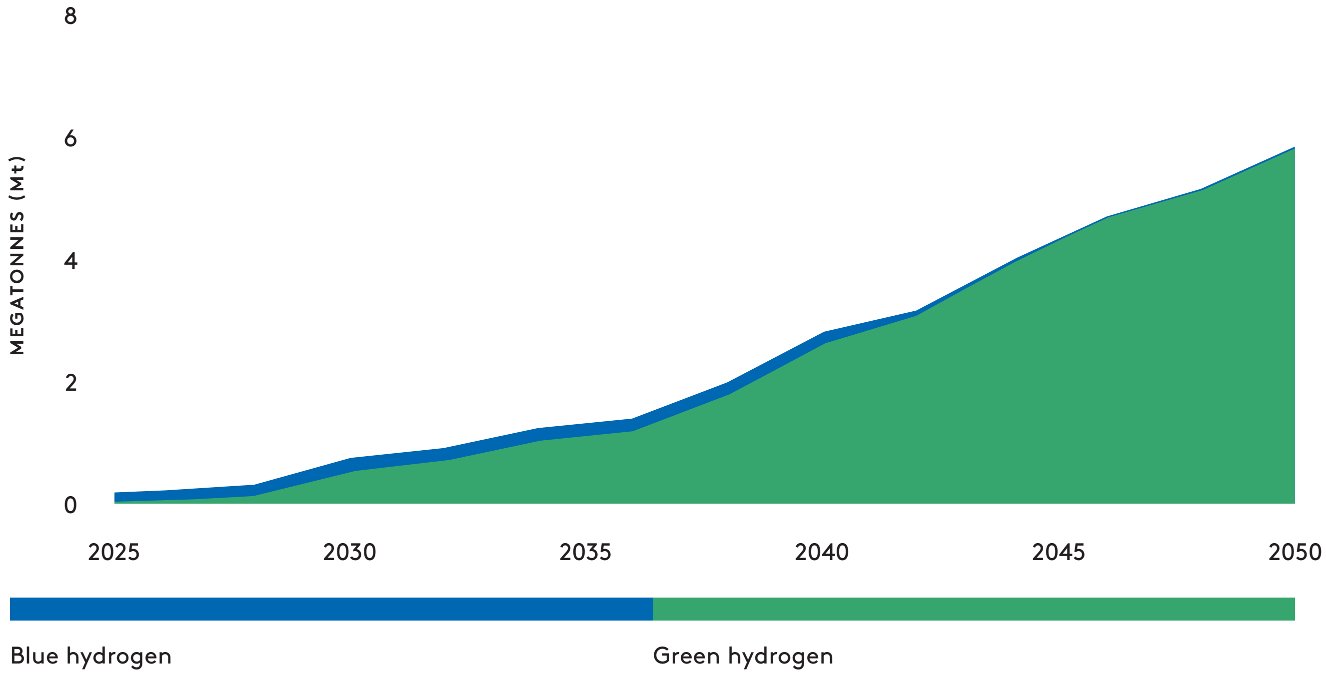



**FIGURE 7.2: Hydrogen production for domestic use in well-below-2°C scenario**




Our modelling shows blue hydrogen plays a role in the short term to help create a domestic market for hydrogen.

As the cost of renewable electricity falls, blue hydrogen quickly gets displaced in the market by green hydrogen produced via renewable-powered electrolysis.

As shown in the figure above, green hydrogen production in Australia grows steadily until 2030 and then increases more rapidly to 2045.

No role for grey hydrogen was found in these scenarios.

# Removing carbon from the atmosphere is critical, so practicalities need to be resolved

Land management practices such as tree planting – and emerging soil carbon technologies – can absorb carbon dioxide from the atmosphere. This complements efforts to reduce emissions in other economic sectors.

Our scenarios suggest an unprecedented scale of effort to absorb carbon dioxide is needed to stay within the Paris Agreement temperature limits.

The graph overleaf shows that the amount of carbon dioxide removal (CDR) varies greatly depending on the level of ambition, from 1.4 gigatonnes of CDR in the well-under-2°C scenario to 4.6 gigatonnes in the 1.5°C scenario.

Most would come from increased uptake of established land-based practices, such as planting trees and ecosystem restoration.

A minority of the carbon removals in the scenarios come from speculative technology such as direct air capture. However, even if this technology does become viable in the future, our modelling does not see a role for it until the 2040s.

CDR in the 1.5°C scenario in 2050 is around 17 times what Australian land currently sequesters each year.

**FIGURE 8.1: Carbon dioxide removals in 1.5°C scenario**

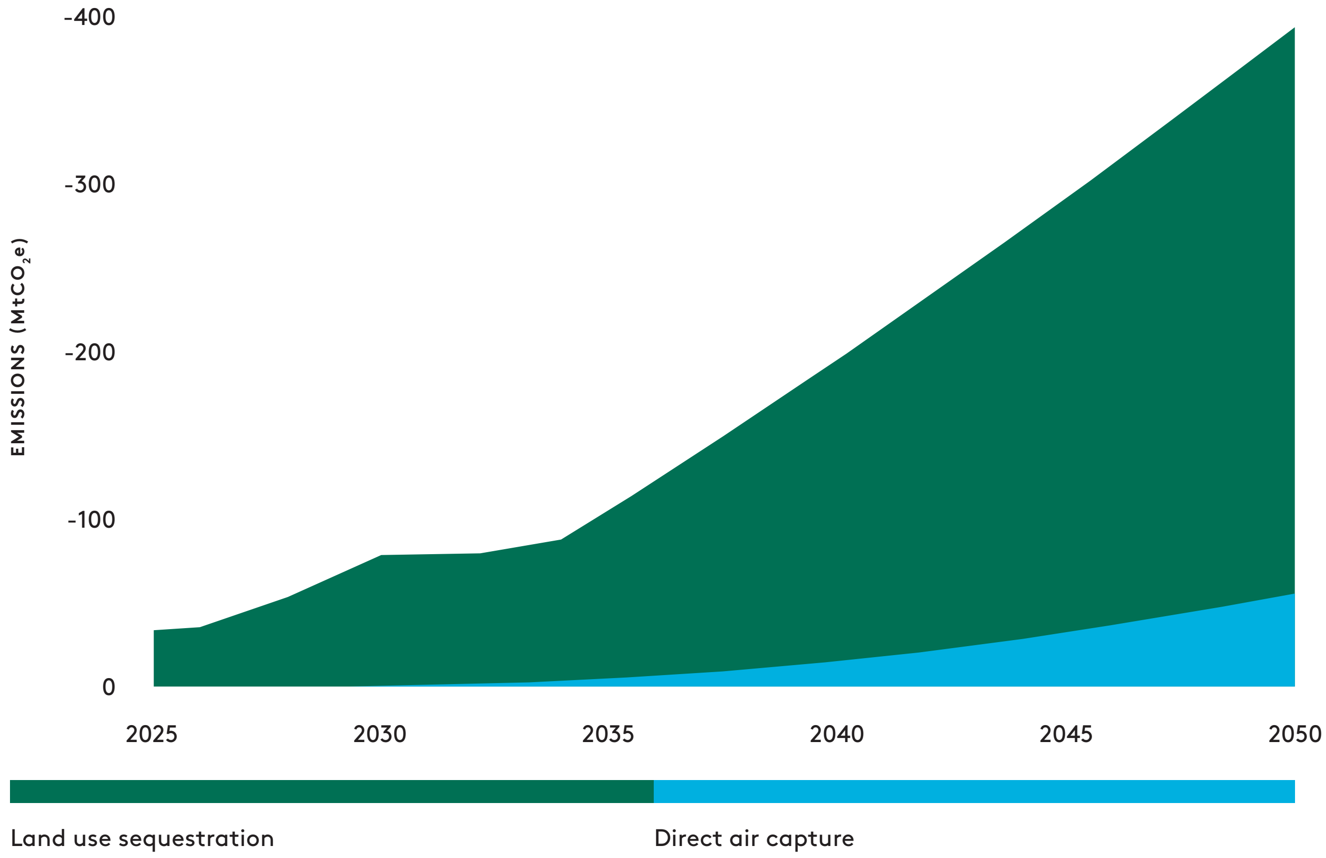
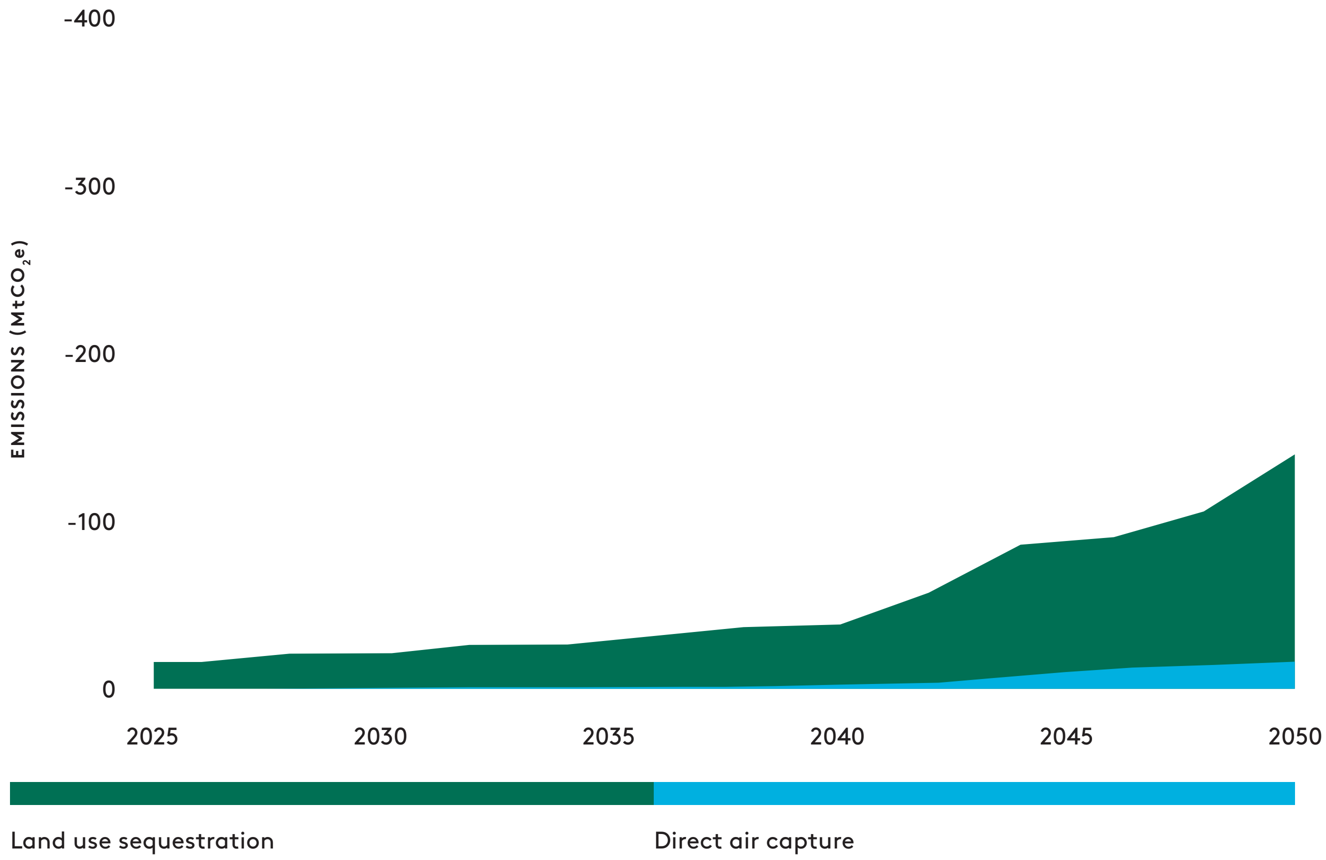



**FIGURE 8.2: Carbon dioxide removals in well-below-2°C scenario**



In our modelling, CDR is not a replacement for efforts to reduce emissions in other sectors.

For example, even before taking CDR into account, total emissions from buildings, transport, industry, energy and agriculture reduce by 56–68 per cent by 2035 compared with 2005 levels.

The model resorts to CDR almost exclusively to counterbalance hard to abate emissions from sources such as livestock, cement production, long-haul trucking and aeroplanes.

In the 1.5°C scenario, the rate of carbon removals kicks up in the 2040s for Australia to stay within its 1.5°C emissions limits.

Some of the emissions categorised as hard to abate today may be reclassified over time as technology progresses.

For example, our modelling for the Australian Industry ETI, showed that with new and emerging technologies it’s possible to reduce emissions in iron, steel and ammonia manufacturing (Climateworks Centre 2023a) — industries that until recently were considered hard to abate.

It's possible that future modelling exercises could require less CDR as technological solutions improve to address more of today's hard to abate emissions.

The scale of CDR in these scenarios presents significant practical challenges that need to be considered, such as how best to use land that has competing economic, environmental or cultural significance.

And as the climate continues to warm, increased heatwaves and flooding will affect nature’s ability to absorb carbon.

Climateworks is currently working with Deakin University to update the Land Use Trade-Offs model that will help answer some of these questions, to complement our AusTIMES model findings.

Find out more about our modelling.

# Everything, Everywhere, All At Once

We started this report referencing the movie *Everything, Everywhere All At Once* as a way of explaining the concept of scenario modelling.

Earlier this year UN secretary general António Guterres also referenced the movie title when calling upon the world to 'massively fast-track climate efforts by every country and every sector and on every timeframe'.

Climateworks' Paris-aligned whole-of-economy scenarios show Australia can heed this call.

They show Australia rapidly decarbonising its electricity system – ending coal generation, reducing gas and more than doubling renewable electricity generation by 2035.

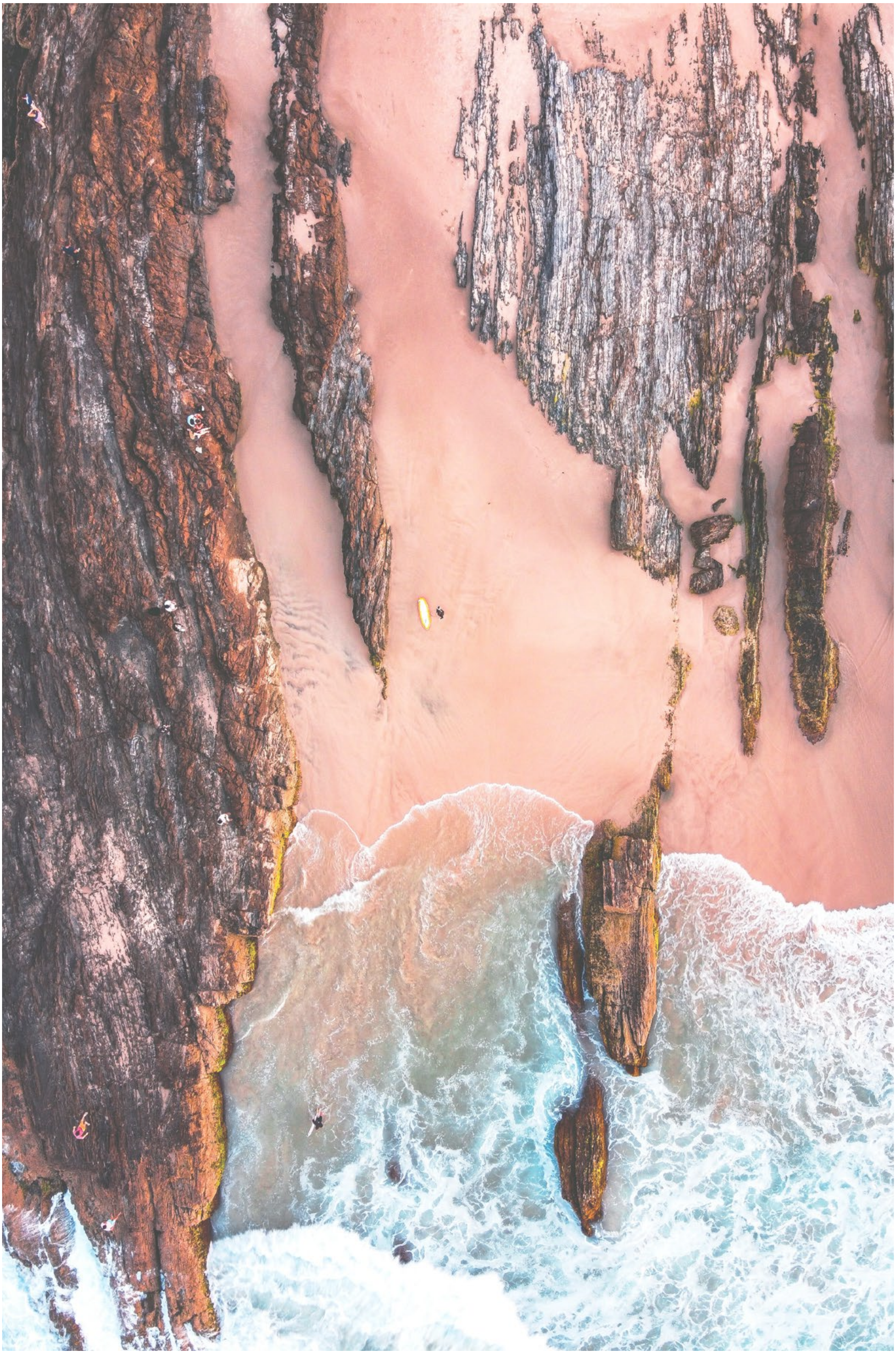
They show renewable electricity powering buildings, transport and industry while the country improves its homes, invests in green hydrogen, plants trees and protects ecosystems.

And they show the nation committing to faster emissions reductions over the next decade and beyond, strengthening its 2030 emissions reduction target and bringing its net zero target forward more than a decade.

If Australia and the rest of the world can follow Paris-aligned pathways, a safer and more prosperous future awaits. Climateworks' 2023 scenarios show two such futures for Australia.

These futures become possibilities if Australia acts quickly, builds on the momentum towards net zero and urgently does the hard work needed to play its part in stopping the worst effects of climate change – while seizing the enormous opportunities that fast decarbonisation presents.

*Climateworks is continuing its work on climate transitions in Australia, South-East Asia and the Pacific.*



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For further information please contact:

**MICHAEL LI**
Research & Analysis Manager
michael.li@climateworkscentre.org

**WEI SUE**
Head of Strategy
wei.sue@climateworkscentre.org

Climateworks Centre
Level 27, 35 Collins Street
Melbourne Victoria 3000
Wurundjeri Country

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